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Review article

The influence of patient portals on users' decision making is insufficiently investigated: A systematic methodological review

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ABSTRACT

Background: Patient portals are considered valuable conduits for supporting patients' self-management. However, it is unknown why they often fail to impact on health care processes and outcomes. This may be due to a scarcity of robust studies focusing on the steps that are required to induce improvement: users need to effectively interact with the portal (step 1) in order to receive information (step 2), which might influence their decision-making (step 3). We aimed to explore this potential knowledge gap by investigating to what extent each step has been investigated for patient portals, and explore the methodological approaches used.

Methods: We performed a systematic literature review using Coiera's information value chain as a guiding theoretical framework. We searched MEDLINE and Scopus by combining terms related to patient portals and evaluation methodologies. Two reviewers selected relevant papers through duplicate screening, and one extracted data from the included papers.

Results: We included 115 articles. The large majority (n = 104) evaluated aspects related to interaction with patient portals (step 1). Usage was most often assessed (n = 61), mainly by analysing system interaction data (n = 50), with most authors considering participants as active users if they logged in at least once. Overall usability (n = 57) was commonly assessed through non-validated questionnaires (n = 44). Step 2 (information received) was investigated in 58 studies, primarily by analysing interaction data to evaluate usage of specific system functionalities (n = 34). Eleven studies explicitly assessed the influence of patient portals on patients' and clinicians' decisions (step 3).

Conclusions: Whereas interaction with patient portals has been extensively studied, their influence on users' decision-making remains under-investigated. Methodological approaches to evaluating usage and usability of portals showed room for improvement. To unlock the potential of patient portals, more (robust) research should focus on better understanding the complex process of how portals lead to improved health and care.

1. Introduction

Patient portals are information systems that provide individuals with access to their health records [1–5]. Further, they support basic activities such as recording symptoms, communication with healthcare providers, or booking appointments online [6]. Many patient portals target people living with chronic conditions, including asthma, cancer, diabetes, and multiple sclerosis [7,8].

Patient portals are seen as a key route to engage patients in care [9–14], and as a valuable conduit to support them with self-managing their health and conditions [7,14,15]. This may explain their increasing availability [16,17], with previous studies reporting high levels of user satisfaction [6,18,19]. Yet, despite their rising popularity and potential, there is no strong evidence for the positive effect of patient portals on health care processes and outcomes [20–24].

The reasons for patient portals' lack of impact are currently poorly understood [20,21]. To address this, others have advocated that evaluations should take into account the complex processes whereby

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health information systems –in our case: patient portals—may lead to improvement [25,26]. Coiera proposed in his 'information value chain' [26] that for a system to have impact, users first need to effectively interact with it (step 1) in order to receive information (step 2), which might then influence their decision-making (step 3). In favourable conditions, this could lead to improved care processes (step 4) and, ultimately, better health outcomes (step 5). This implies that, to understand why a system fails to induce change in step 4 and 5, we need to focus more on investigating steps 1–3.

Many studies in patient portals so far have focused on steps 4 and 5: several systematic review evaluated the effect of patient portals on care processes and health outcomes [20–24]. For example, de Lusignan et al. [22] included 143 studies in their systematic review to investigate the effect of patient portals on provision, quality and safety of healthcare, while also appraising the quality of these studies. Giardina et al. [21] included 20 randomized controlled trials and seven observational studies to explore the impact of patient portals on effectiveness, efficiency, timeliness, patient-centeredness, and equity. Another review focused on the effect on chronic conditions outcomes and identified 27 studies [17]. In contrast, there seems to be a knowledge gap for steps 1–3 in the context of patients portals, with only one realist review [27] focusing on identifying factors related to patients' engagement with the system which –among other things– included usage and usability.

Therefore, as this potential gap in knowledge might conceal some of the reasons for the current lack of impact of patient portals, our study aimed to investigate to what extent steps 1–3 have been investigated for patient portals. To achieve this, we systematically reviewed the literature to identify studies that evaluated usage, usability and effect on decision-making of patient portals. We describe which specific aspects these studies evaluated and report on the methodological approaches they employed in order to provide further insight into how extensively Coiera's Information Value chain Steps 1–3 were investigated. We anticipate that our review will provide pointers for Health Informatics research by revealing aspects of patient portals that warrant further studies.

2. Materials and methods

We followed the PRISMA statement [28] to design and report our systematic review, where applicable.

2.1. Theoretical framework

We used Coiera's 'information value chain' as the theoretical framework [26] to guide our study selection and data synthesis. This theoretical framework was especially suitable for our study because it conceptualizes in five steps how the use of a health information system of any type might lead to a change in health outcomes [26]. Also, a main feature of the information value chain relevant to our study aim is that each step can be evaluated and quantified on its own, with positive results in one step increasing the likelihood of obtaining improvements in the next steps.

If we apply Coiera's framework to patient portals, the chain starts with patients interacting with the system (step 1), which for example can be evaluated in terms of usability or usage (e.g. if and how often patients logged into the system). From some interactions, patients will receive information from the system (step 2). The amount and type of information received will depend on which patient portal functionalities patients accessed. This could be, for example, viewing a medication or problem lists, or laboratory results. Where the portal functionality allows patients to record information such as symptoms, the quantity and accuracy of data logged into the system can be evaluated. Step 3 will then focus on whether this information led to patients and clinicians making or changing a decision. For example, patients could decide to contact their healthcare provider if they are worried about an out-of-range laboratory result, or notify their general practitioner of an incorrect medication entry in their health record. At the same time, information recorded by patients through the portal might lead to a clinician requesting an extra laboratory test, or updating the medication list. In both cases, one can count the number of decisions that changed and evaluate their appropriateness. Ultimately, these decisions may alter the process of care (step 4), such as a change in utilisation of the health care resources, patient activation or medication prescriptions. In some cases, such changes will lead to better health outcomes (step 5), such as improvements in blood sugar control or quality of life.

In our review we focused on identifying studies that evaluated aspects of patient portals related to the first three steps of Coiera's information value chain (i.e. interaction with the system, receipt of information, and influence on decision making) [26].

2.2. Search strategy

In compliance with guidance from the Cochrane collaboration [29], we searched MEDLINE via Ovid [30] and Scopus [31] for articles in English using both words in title, abstract, or keywords as well as standardized indexing terms. We combined terms referring to patient portals with terms pertaining to evaluations of system usage; usability and decision-making that reflected Coiera's information value chain steps 1–3; Supplementary file A contains the search syntax for both databases. The searches were performed on the 18th of July 2016; without limits on year of publication.

2.2.1. Selection of relevant studies

The inclusion criteria for our review spanned across four areas:

- Type of system; We included studies that evaluated a patient portal, following the definition of patient portals from Irizarry et al. [27]. This included systems that were either "tethered" or "untethered" to an Electronic Health Record (EHR), as well as prototypes or mock-ups of patient portals. We focused on systems that gave users access to (part of) their medical records (e.g. laboratory test results, medications or problem lists), allowed them to enter health data, or share it with healthcare professionals. We excluded systems that only provided patients with educational material, or online booking or secure messaging functionalities. Included studies could focus on a specific system or more than one system at the same time.
- Target population; We were interested in studies that had patients, carers, or healthy volunteers from the general population as the study sample, as they are the people most commonly targeted by patient portals.
- Aspects evaluated; We included articles that reported findings on patient portal use, i.e. related to the first three steps of Coiera's information value chain [26], obtained from experiments in controlled laboratory settings, as well as from field studies in a real world context. We excluded studies that only evaluated the intention to use patient portals. We also excluded studies solely reporting on the impact on care processes or health outcomes (steps 4 and 5 from Coiera's information value chain) as such studies and their methodological quality have been already investigated in previous systematic reviews [20–24].
- Publication type; We were interested in systematic reviews or original articles in English. We included full papers published in conference proceedings, while excluding conference abstracts. Narrative reviews, editorials, view point papers and grey literature were also excluded.

After removing duplicates from the MEDLINE and Scopus searches, the principal reviewer (PF) independently screened the titles and abstracts of all studies, whereas two others (PB; SvdV) each did half. For studies considered potentially relevant, we retrieved the full papers to

decide on final inclusion, which was also done independently and in duplicate by two reviewers (PF; SvdV). At both stages, disagreement was solved through discussion.

2.3. Data extraction and synthesis

We developed a data abstraction form building on previous reviews of patient portals [23,32] and usability evaluations of health information systems [25,33,34]. These reviews provided a comprehensive set of items from which we selected the most relevant ones for our review. This was achieved through discussion among the authors (PF, SvdV, MV, NP), considering completeness and clarity of potentially relevant items. The final form included items related to general study characteristics; study population; type of patient portal (tethered or untethered); patient portal functionalities (access to records; data recording; data sharing); study design (within-subject; between-subject; mixed); setting (field, laboratory or remote); guided by theoretical framework (yes or no); which of the three steps of Coiera's were investigated (interaction; information received; decision making); evaluation methods; and metrics reported. In line with the aim of our review we focused on identifying methodological approaches, and thus did not extract information on study findings. Also, since we intended to provide a comprehensive overview of studies without summarising their results through meta-regression, we did not critically appraise study quality. For studies that used questionnaires as an evaluation method, we also recorded if the adopted instrument had been previously validated, based on previous work, or developed for the specific study (i.e. ad-hoc questionnaire). One author (PF) extracted the data for all studies, resolving uncertainties through discussion with a second member of the research team (SvdV).

We performed a qualitative synthesis of the extracted data and organised our results according to the steps in Coiera's information value chain. For each step, we highlighted the different aspects that were evaluated, the method used, and commonly reported metrics.

3. Results

The searches from MEDLINE and Scopus yielded 1379 potentially relevant articles. Of those, 161 were selected for full-text screening, resulting in a total of 115 studies to be finally included in the review (Fig. 1) [1,3,35–147].

3.1. Study characteristics

Tables 1–3 display a summary of the information extracted on the characteristics and design of the 115 included studies, and the patient portals they evaluated; full details of each included study are provided in Supplementary file B.

3.1.1. General study characteristics

Out of all studies we found 111 unique projects. Some studies reported different analyses from the same project [64,108,124,147], whereas others reported preliminary [65,115] and final results [1,63] of the same project separately. Table 1 shows their characteristics. The majority were performed in the United States (n = 81; 74%), were published after 2010 (n = 73; 66%), had patients with a specific condition as their study population (n = 39; 34%), and had more than 100 participants (n = 59; 53%).

3.1.2. Type of patient portals evaluated

The 115 included studies reported evaluations of a total of 80 different patient portals. Eighteen were tested in more than one study, with a median of two studies (range, 2–10) reporting on the same patient portal. MyChart (n = 10, see Supplementary file C.1 for references) and Patient Gateway (n = 9, see Supplementary file C.2 for references) were the patient portals that appeared in most studies. The majority of the tested patient portals were tethered (n = 58, 73%), and 32 (40%) were prototypes (Table 2). Data recording functionalities and access to records were provided by 53 (66%) and 58 (73%) of patient portals, respectively.

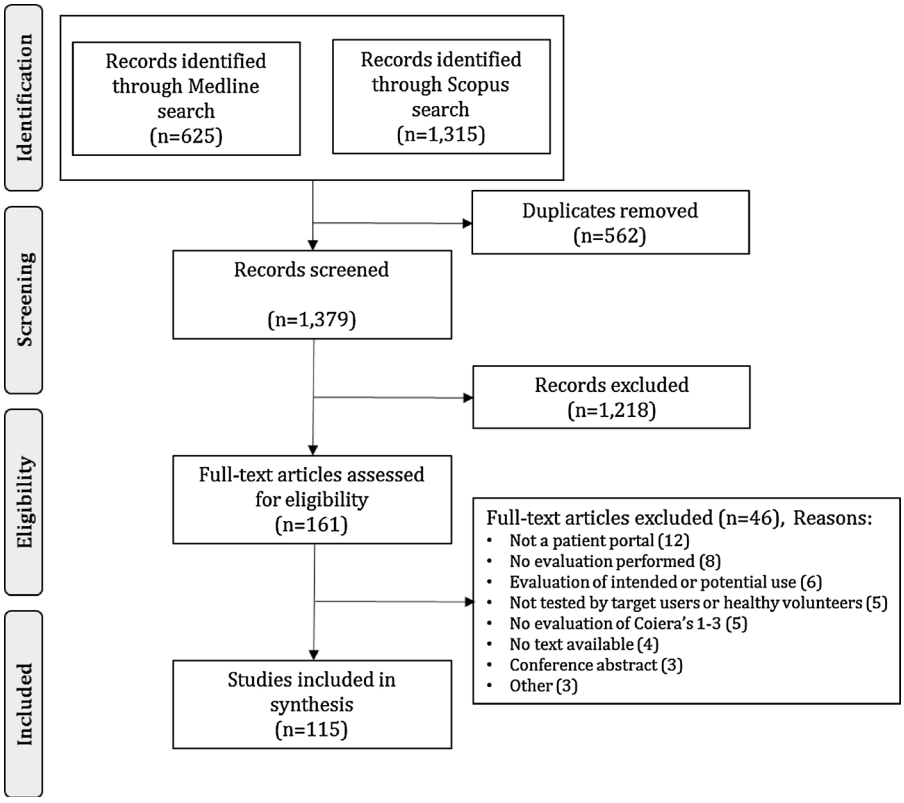

Fig. 1. Flow diagram of screening and inclusion of relevant studies.

Table 1
General characteristics of included unique projects (total n = 111).

General study characteristics	N (%)	References
Year of publication		
Before 2005	7 (7)	[1,42,66,81,82,85,86,115]
From 2005–2010	31 (27)	[36,39,40,43,45,47,50,51,54,57,59,71,74,78,83,95,100,101,106,109–112,114,116,118,125,128,133,145,146]
After 2010	73 (66)	[3,35,37,38,41,44,46,48,49,52,53,55,56,58,60–65,67–70,72,73,75–77,79,80,84,87–94,96–99,102–105,107,108,113,117,119–124,126,127,129–132,134–144,147]
Georgraphical location		
United States	81 (74)	[1,36–38,41–47,50–56,59,62–68,71–73,75,78–83,86–88,90–93,96–99,101–103,105–110,115,118–123,125–133,135–140,142–146]
Europe	17 (15)	[3,35,40,48,58,60,70,74,77,84,85,94,100,104,111,112,114]
Canada	8 (7)	[39,57,61,69,76,89,95,113]
Other	5 (4)	[49,117,124,134,141,147]
Study population		
People living with a specific condition	39 (34)	[36,38,41,42,46,48,51,54,55,58,60–62,65,69,70,73,76,77,79,81,84,86,90–92,94,95,103,104,106,114,122,125,126,131,134,141,143]
General population	34 (32)	[1,43–45,47,53,56,63,64,66,67,71,72,75,82,87,93,97,98,100,102,108,110,111,113,115–118,120,121,124,127,135,140,142,147]
Primary care patients	25 (22)	[3,35,40,50,52,59,68,85,88,96,99,105,106,112,119,123,130,132,133,136–138,144–146]
Carers	8 (7)	[37,78,80,83,89,101,109,129]
Other	5 (4)	[39,49,57,74,128]
Sample size		
< 30	28 (26)	[1,35,37,40,41,43,44,48,49,51,53–55,63,65,73,75,76,81,83,89,105–107,109,112–115,141]
Between 30 and 100	20 (18)	[36,45,57,58,60–62,66,71,80,85,86,88,97,98,100,103,110,111,135]
More than 100	59 (53)	[3,38,39,46,47,50,52,56,59,64,67–70,72,74,77–79,82,84,87,92–96,99,101,104,108,116–134,136–140,142,144–147]
Not reported/unclear	4 (3)	[42,90,91,102]

Table 2
Type of patient portal evaluated (total n = 80).

Type of patient portal evaluated	N (%)	References
Patient portal type		
Tethered	58 (73)	[1,3,37–40,42,46,48,50,52,54,56,58–70,72,74–77,79,80,82,84–99,101–111,113–117,119,122,123,125–133,135–140,143–146]
Untethered	22 (28)	[35,36,41,43–45,47,49,51,53,55,57,71,78,81,83,100,112,118,120,121,124,134,141,142,147]
Prototype[a]		
Yes	32 (40)	[35,37,41,51,53–55,60,61,66,67,73,78,79,81,83,86,89,93,100,106,107,109,110,112–114,122,141–143]
No	51 (64)	[1,3,36,38–40,42–50,52,56–59,61–63,65,68–72,74–77,80,82,84,85,87,88,90–92,94–99,101–105,108,111,115–121,123–140,144–147]
Main functionalities[a]		
Access to records	58 (73)	[1,3,37–40,42,46,48,50,52,56,58–70,72–77,79,80,82,84–99,101–111,113–117,119,121–123,125–133,135–140,143–146]
Data recording	53 (66)	[1,35–38,40–60,64,67–69,71–73,75,77,78,80–84,86,87,90,94–98,100,104,108,110–121,123–128,131–136,138,139,141,142,144–146]
Data sharing	30 (38)	[1,35–37,42–45,47,48,50,54,59,60,68,69,71,72,77,80,86,96,98,100,110–112,114–117,119,121,125,128,131–134,136,144–147]

[a] Categories are not mutually exclusive.

3.1.3. Setup of included studies

Most of the 115 included studies (n = 93; 81%) followed a within-subject design, were longitudinal (n = 69; 40%), and were carried out in the field (n = 84; 73%) (Table 3). In a minority of studies (n = 14; 12%), authors explicitly referred to a theoretical framework they used to guide their analysis, with the Technology Acceptance Model [148] and Nielsen's usability heuristics [149] being the most frequently cited.

3.2. Evaluated aspects and adopted methods

Fig. 2 displays the number of included studies for Coiera's information value chain steps 1–3, as well as a summary of the main aspects investigated for each step. Table 4 reports in more detail which aspects were investigated and which evaluation methods were applied.

Overall, interaction with patient portals (Coiera's step 1), users receiving information (step 2), and influence of patient portals on patients' and clinicians' decisions (step 3) were evaluated in 104 (90%), 58 (50%) and 11 (10%) studies, respectively. Overall, 49 studies (43%) looked at two steps out of the first three in Coiera's information value chain (see Supplementary file C.3 for references). Only four studies (4%) [3,124,132,134] considered all first three steps. Furthermore, of the 80 unique systems we found, step 1 was evaluated in 77 (96%) cases, step 2 in 41 (51%), and step 3 in nine (11%) systems. Overall, 39 systems (49%) had only one of the three steps evaluated, while 35 (44%) had two, and six systems had all of the first three Coiera's steps evaluated.

Usage (n = 61) and overall usability (n = 57) were the most assessed aspects for step 1. Usage was commonly evaluated by analysing system interaction logs (83%), with 47 studies (see Supplementary file C.4 for references) reporting the percentage of active users (i.e. mostly defined as patients using the system at least once). Overall usability mainly referred to user experience and satisfaction and was primarily evaluated with questionnaires (n = 55); in eleven studies the questionnaire was validated or based on previous work (n = 11) (see Supplementary file C.5 for references). Less commonly assessed specific usability features regarded user interface issues (n = 15) and interaction effectiveness (n = 20) and efficiency (n = 12).

The usage of specific patient portals functionalities was the most commonly assessed aspect (n = 48) to evaluate Coiera's step 2. Methods and metrics were similar to studies evaluating overall system usage described above; eleven studies also reported the frequency of patient portal functionality use or number of actions per session (see Supplementary file C.6 for references).

Of the five studies evaluating the influence of patient portal use on patients' decisions (step 3), four reported the percentage of patients who said to have implemented life style changes [3,124,132,134]. The six studies evaluating the influence on clinicians' decisions mostly reported the number of additional clinical actions (e.g. identifying potential adverse events [119,135,136]) that could be implemented based on information from the portal.

4. Discussion

4.1. Summary of findings

We performed a systematic review of the literature on evaluations of patient portal usability, usage and influence on decision-making. Our review was guided by Coiera's information value chain as a theoretical framework. Our main finding is that almost all included studies evaluated interaction with the patient portal, whereas only 50% and 10% assessed the information received from the system and its influence on decision making, respectively. As for the methodological approaches applied, usability was mostly evaluated using non-

Table 3
Setup of included studies (total n = 115).

Evaluation characteristics	N (%)	References
Study design		
Within-subject	93 (81)	[1,3,35,37,38,40–47,49–59,63–67,69–78,81–86,88–92,94–110,112–118,120,121,123–130,132,135,138–142,144,145,147]
Between-subject	20 (18)	[36,39,48,60–62,79,80,87,111,119,122,129,131,133,134,136,137,143,146]
Mixed	2 (2)	[68,93]
Temporal factor		
Cross-sectional	45 (39)	[3,37,43–46,48,51,53,54,62–65,67,71–73,75,78,79,81–83,85,89,93,97,98,103,105–109,112,113,118,120,122,126–128,132,141]
Longitudinal	69 (60)	[1,35,36,38–42,47,49,50,52,56–61,66,68–70,74,76,77,80,84,86–88,90–92,94–96,99–102,104,110,111,114–117,119,121,123–125,129–131,133–140,142–147]
Mixed	1 (1)	[55]
Study setting[a]		
Laboratory	30 (26)	[37,43–45,51,53–55,63–65,71,75,81,83,85,89,93,97,98,105–110,112,113,141]
Field	84 (73)	[1,3,35,36,38–42,47–50,52,55–62,66–70,72–74,76,77,80,82,84,86–88,90–92,94–96,99–104,111,114–140,142–147]
Remote	4 (4)	[46,55,78,79]
Theoretical framework used		
Yes	14 (12)	[37,41,46,62,73,78,91,105,106,111,112,144,147]
No	101 (88)	[1,3,35,36,38–40,42–44,47–61,63–72,74–77,79–90,92–104,107–110,113–123,125–143,145,146]

[a] Some publications reported on different phases of the study, reporting multiple study settings and ecologies.

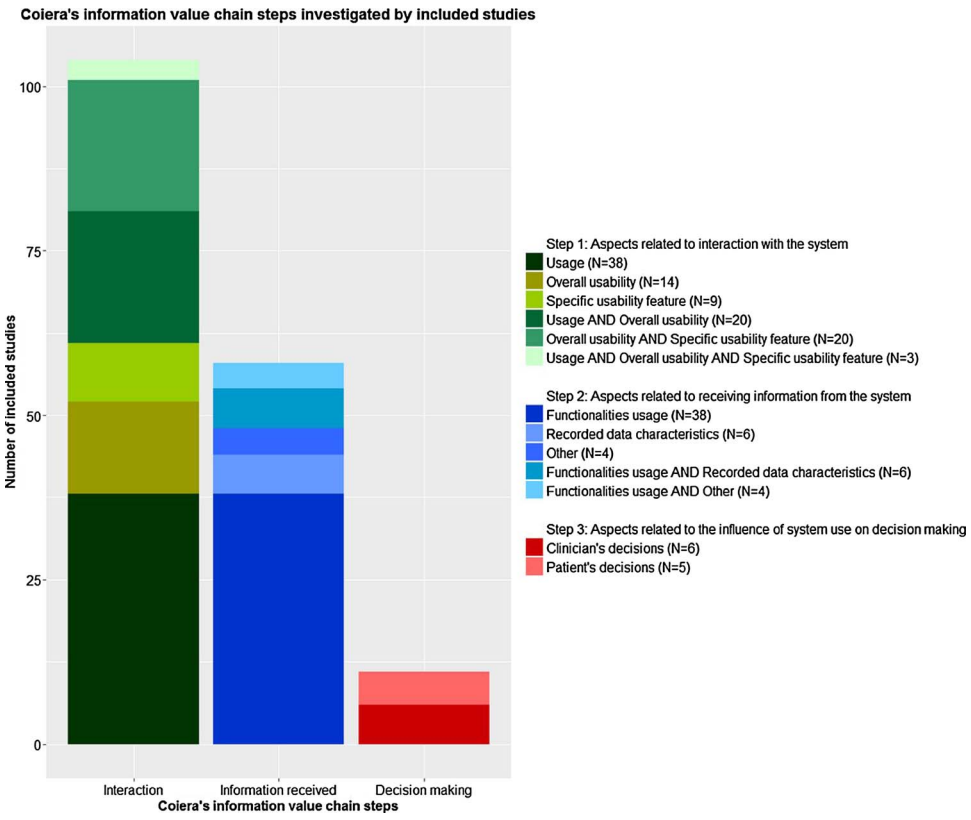

Fig. 2. Number of included studies for step 1–3 of Coiera's information value chain. For each step, the stacked bar summarises which aspects were investigated.

validated questionnaires. Usage was assessed through system interaction log analysis, with 'active users' commonly defined as those logging in at least once. The few studies that looked at the influence on decision making used self-reported questionnaires (patients) and data logs (clinicians).

4.2. Relation to other studies

Although many systematic reviews have been recently published on patient portals [6,15,20–22,24,32,150], ours is the first that focused comprehensively on usability, usage and decision making from a methodological perspective. In addition, a secondary analysis of the included studies evaluating usage allowed us to perform a meta-analysis that showed how adoption rates of patient portals are low, especially when assessed in real-world experiments (i.e. after deploying a patient portal into clinical practice) [151]. This might further contribute in understanding the current lack of impact of patient portals.

Irizarry et al. [27] performed a realist review that identified factors influencing patients' engagement with patient portals. Although they did not aim to review the methodologies used in the included studies, they also reported that studies often considered patients as active users if they logged in at least once. Furthermore, they identified 20 studies that considered usability of patient portals, most of which used questionnaires.

Our findings are also in line with two methodological systematic reviews that looked at usability studies of Electronic Health Record systems [34] and current practice in usability studies [33] that found that usability effectiveness and efficiency were infrequently evaluated. This is surprising given that effectiveness and efficiency are defined as essential usability qualities by standardization documents including the ISO 9241-11 [152]. Furthermore, Hornbæk et al. [33] already concluded in 2006 that most studies evaluating usability through questionnaires used non-validated instruments that were often designed ad hoc for the study in question. Our review showed that ten years after Hornbæk's review this methodological issue still often goes unaddressed in patient portal evaluations.

4.3. What is the meaning of the findings and what are their implications?

To better understand how patient portals can change decision making, each of the steps in Coiera's information value chain should be evaluated. Ideally this happens for the same system within a single study context. However, less than half of the portals had two steps in the information value chain addressed, and there were only six for which all three steps had been evaluated.

Furthermore, we observed that the number of studies that focussed on the first three steps of Coiera's information value chain decreased steeply along the chain: whereas the interaction with the system was addressed in 104 studies, receiving information from patient portals and their influence on decision making was only evaluated 58 and 11 times, respectively. As a chain can only be as strong as its weakest link, some of the unknown reasons for patient portals' lack of impact might be concealed by the influence on decision making being an under-investigated aspect. A potential explanation for this apparent knowledge gap is that metrics to assess the influence of patient portals on decisions are less straightforward than for the other steps in Coiera's information value chain. This is especially true for patients, for whom the recording of decisions (e.g. changing one's life style or self-management behaviour) commonly relies on unstructured self-reports during clinic visits or using intermittent questionnaires. Opportunities to measure these decisions are likely to increase in the future through the advent of smartphone apps and wearable technology, allowing patients to more continuously and systematically record health behaviours in the context of their everyday lives [153]. Future studies should take advantage of these opportunities to further investigate the impact of patient portals on decisions.

From a methodological perspective, there may be room for im-

Table 4
Synthesis of methods used to evaluate Coiera's steps 1–3.

Evaluated aspects	Evaluation methods	N (%)[a]	References
Step 1: Aspects related to the interaction with the system (n = 104)			
Overall usability (n = 57, 55%)	Questionnaire	55 (96)	[1,35,37–39,41,42,46–48,50,54,55,57–63,65–68,70,71,76,78–80,82,85,86,89,93,95,97,98,105–109,111,112,114,115,118,121,122,125,132,141,143,144]
	Interview or focus groups	9 (16)	[1,51,58,61,73,82,108,115,143]
Specific usability feature – Identifying user interface issues (n = 15, 15%)	Think-aloud	11 (73)	[37,43,53,73,83,105,107,109,112,113,141]
	Interviews or focus groups	6 (40)	[44,73,75,105–107]
	Video recording or observations	4 (27)	[44,51,73,75]
	Questionnaire	1 (7)	[43]
Specific usability feature – Effectiveness (n = 20, 19%)	Tasks analysis	19 (95)	[37,43,45,63,64,71,78,79,81,83,89,93,97,98,107–109,122,141]
	System interaction logs analysis	1 (5)	[58]
Specific usability feature – Efficiency (n = 12, 12%)	Task analysis	11 (92)	[43,44,63,65,75,83,85,93,109,112,141]
	User interface Event Mining	1 (8)	[43]
	Questionnaire	1 (8)	[83]
	System interaction logs analysis	1 (8)	[86]
Usage (n = 61, 59%)	System interaction logs analysis	50 (83)	[1,38–41,47,50,52,55–61,66,68,69,73,76,77,84,87,88,90–92,94,96,99,101,102,104,110,111,115–117,119,123,125,127,129–131,134,137,140,142,146]
	Questionnaire	10 (15)	[3,46,70,72,80,103,122,124,126,147]
	Data log analysis	1 (2)	[36]
Step 2: Aspects related to receiving information from the system (n = 58)			
Usage of different functionalities (n = 48, 79%)	System interaction logs analysis	34 (72)	[1,38,39,41,42,49,56–58,60,68,73,86–88,90,92,94,99,101,110,115–117,123,125,129,131,133,136–140]
	Questionnaire	9 (19)	[3,46,47,70,72,95,120,124,144]
	Data log analysis	5 (11)	[38,50,59,134,135]
Record completeness, quality or quantity (n = 11, 19%)	Data log analysis	10 (91)	[35,36,50,57,59,100,114,128,133,136]
	Questionnaire	2 (9)	[3,132]
Records shared with healthcare professionals (n = 4, 7%)	System interaction logs analysis	3 (75)	[59,125,136]
	Data log analysis	1 (25)	[50,133]
System resource utilisation (n = 5, 9%)	System interaction logs analysis	3 (60)	[42,55,74]
	Google Analytics	2 (40)	[52,121]
Behavioural styles (n = 3, 5%)	System interaction logs analysis	2 (67)	[88,99]
	Factor analysis	1 (33)	[74]
	Interviews	1 (33)	[88]
	Hierarchical clustering	1 (33)	[99]
Step 3: Aspects related to the influence of system use on decisions (n = 11)			
Patients' decisions (n = 5, 45%)	Questionnaire	5 (100)	[3,79,124,132,134]
Clinicians' decisions (n = 6, 55%)	Data log analysis	6 (100)	[100,119,128,135,136,145]
	Interviews	2 (33)	[119,136]

[a] Percentages are calculated for each aspect separately.

provement in patient portal evaluation studies. First, considering people who logged into a system once to be active users is likely to be over-simplistic. As with any new technology, most people will try out a portal before they continue to actually use it. More complex and comprehensive metrics that combine frequency of system and functionality usage may be more appropriate for usage evaluations [154]. Second, authors of future studies should consider using validated questionnaires to evaluate usability, user satisfaction, and user experience [33,155–159]. This could address concerns about the validity of the results, as well as enhance the comparability of these results across studies [33,155].

4.4. Limitations

This systematic review has several limitations. First, we adopted a specific perspective to investigate our research question by choosing Coiera's information value chain. Although it is an established theoretical framework that effectively describes the evaluation of informatics systems, our findings have been biased towards the steps of that chain. This implies that other aspects that are likely to influence whether patient portals lead to improved health outcomes, such as socio-economic factors and health system characteristics, were out of scope for our review. Second, identifying studies for some steps in the chain may have been easier than for others. Whilst we used a comprehensive strategy and used multiple search terms to address each step, we cannot exclude that our search strategy was more sensitive towards steps with more text words and MeSH terms available. Third, we did not perform the data extraction in duplicate. Therefore, this phase of the reviewing process might have been more prone to errors than the others; it was up to the discretion of the primary reviewer to discuss items that were less straightforward to extract and that required more interpretation.

5. Conclusions

Our systematic review highlights clear gaps in the evidence base for patient portals. The most important one is the scarcity of studies investigating the influence of patient portals on the decisions made by patients and clinicians. Furthermore, the majority of studies investigating user interaction with patient portals have employed suboptimal methods. Addressing these gaps through more (robust) research is likely to uncover important reasons for why current patient portals seem to have such little impact on health outcomes.

Conflict of interests

None declared.

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Contributors

PF, SvdV and NP conceived and designed the study. PF, PB, MV and SvdV were involved in data collection and synthesis. PF, MV, IB, NP and SvdV drafted the manuscript. All authors critically revised the work for important intellectual content, and approved the final version of the manuscript for publication.

Summary points

What was already known?

- Patient portals are increasingly available and aim at supporting patients' self-management.
- It is unclear why often patient portals fail to impact on health care processes and outcomes.
- This might be because studies frequently focus only on the final outcomes, rather than on the complex process that leads to them (i.e. interaction with the system, information received from the system, and its influence on decision making).

What this study adds?

- There is little evidence around the influence of patient portals on patients and clinicians decisions;
- Usability and usage of patient portals is mainly assessed with suboptimal methodologies.
- More (robust) research in usability, usage and influence on decision-making is likely to uncover important reasons behind the lack of patient portals impact.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ijmedinf.2017.12.028.

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